

NASA TECHNICAL TRANSLATION

NASA TT F 16,080

MARS-5: SURFACE AND ATMOSPHERE OF THE RED PLANET

L. V. Ksanfomaliti

(NASA-TT-F-16080) MARS-5: SURFACE AND
ATMOSPHERE OF THE RED PLANET (Scientific
Translation Service) 14 p HC \$3.25

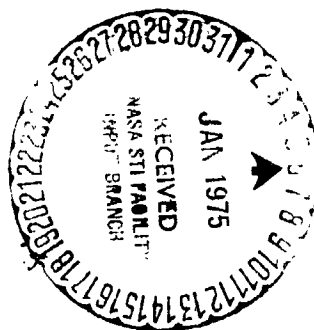
N75-13771

CSCL 03L

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G3/91 24964

Translation of: "'Mars-5': Poverkhnost'
i atmosfera krasnoy planety," Zemlya i
vselennaya, No. 5, 1974, pp. 7 - 11.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 DECEMBER 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F 16,080		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle "MARS-5": SURFACE AND ATMOSPHERE OF THE RED PLANET				5. Report Date 23 December 1974	
				6. Performing Organization Code	
7. Author(s) L. V. Ksanfomaliti				8. Performing Organization Report No.	
				10. Work Unit No.	
9. Performing Organization Name and Address SCITRAN box 5456 Santa Barbara, CA 93108				11. Contract or Grant No. NASw-2483	
				13. Type of Report and Period Covered Translation	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546				14. Sponsoring Agency Code	
15. Supplementary Notes Translation of: "'Mars-5': Poverkhnost' i atmosfera krasnoy planety," Zemlya i vselennaya, No. 5, 1974, pp. 7 - 11.					
16. Abstract The operation of Mars-4 and Mars-5, launched to Mars in August, 1973, is discussed. The scientific information is briefly described. It was found that the argon content in the Martian atmosphere is about 35%, which is very large. Additional data indicate the surface rocks are highly pulverized. PRECEDING PAGE BLANK NOT FILMED					
17. Key Words (Selected by Author(s))			18. Distribution Statement Unclassified - Unlimited		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 12	22. Price		

"MARS-5": SURFACE AND ATMOSPHERE OF THE RED PLANET

L. V. Ksanfomaliti*

In February and March, 1974, the spacecraft "Mars-4, -5, -6, and -7", which were launched in August, 1973, approached the red planet. Along with a great amount of scientific measurements, "Mars-4 and -5" transmitted photographs of the planet surface from a distance of more than 200,000,000 km.

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The problem of developing an artificial satellite of Mars and placing equipment on its surface was divided up as follows: "Mars-4 and -5" would be its satellites, and "Mars-6 and -7" carried equipment which could be landed. On 12 February 1974, "Mars-5" entered the orbit of an artificial satellite of Mars and rapidly began to perform scientific measurements. Within a month, "Mars-6" had achieved its objectives, and equipment had been landed on the surface of the planet. Results of scientific measurements were transmitted from the equipment to "Mars-6" and then returned to the Earth. As has been reported, in the immediate vicinity of the surface of the planet, radio communication with the equipment was disrupted.

Due to the malfunctioning in one of the onboard systems, "Mars-4" did not enter the orbit of an artificial satellite of Mars. It flew at a distance of 2200 km from its surface and took television pictures. The spacecraft "Mars-7" also passed at a distance of 1300 km from the surface of the planet.

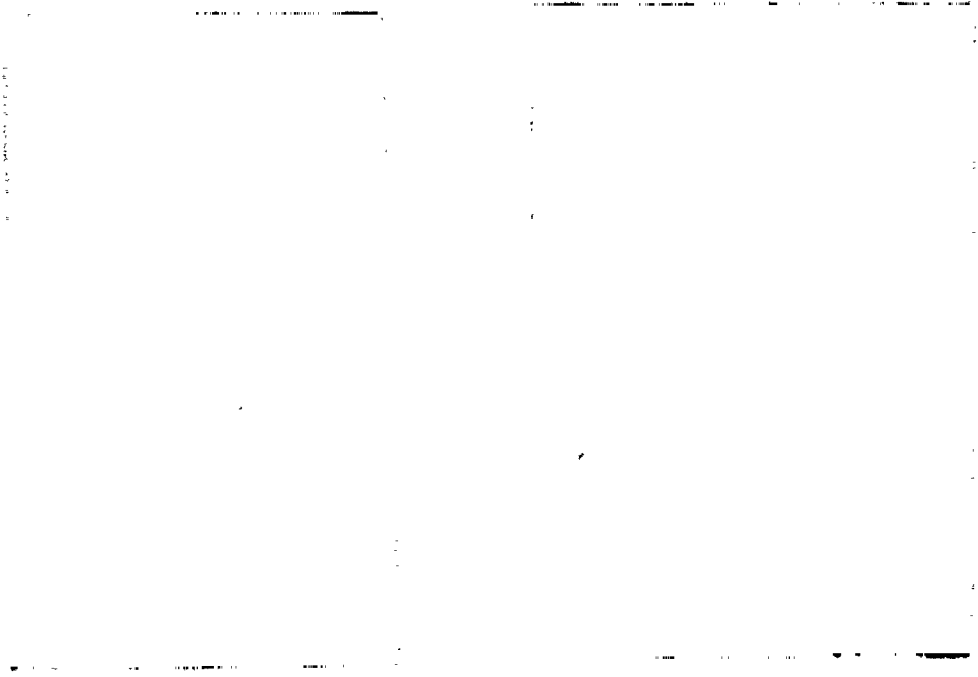
*Candidate of Physico-Mathematical Sciences.

**Numbers in the margin indicate pagination of original foreign text.

The large amount of scientific information obtained from "Mars-5" has greatly expanded our knowledge regarding the red planet. "Mars-5" is an orbital astrophysical observatory. The results obtained from the astrophysical complexes "Mars-2 and -3" and "Mariner-9" in 1971 — 1972 have been very highly regarded by scientists. ("Zemlya i vselennaya, No. 5, 1973, pp. 2 — 17. — Editor.) As compared with its predecessors, "Mars-5" has provided much greater scientific information. Experiments performed on "Mars-3" were very diverse and were supplemented by new experiments, including experiments performed for the first time. With respect to the equipment which is continuing the studies which were begun in 1971 — 1972, it has undergone significant changes, and the possibilities, accuracy, and sensitivity have been greatly expanded. The total number of experiments on "Mars-5" has exceeded twenty. We shall only consider a few of them.

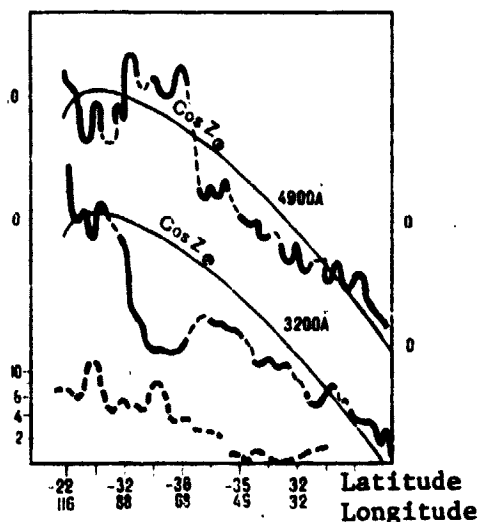
The problems solved by "Mars-2 and -3" and "Mariner-9" have raised new problems in turn. Where has the water gone, which has left such pronounced traces on the surface of Mars? How old are the ancient river beds? Why is the atmospheric pressure on the surface of the planet suspiciously close to the triple point of the phase state of water, of which there is practically no trace in the atmosphere? What was the atmospheric pressure when there were rivers on the surface of Mars? Why has nitrogen not been found in the atmosphere? What mechanisms are in operation in the upper atmosphere, where the shortwave portion of the incoming solar radiation is absorbed? These and many other questions will not only require new experiments, but researchers must also advance new concepts about Mars in order to determine the interrelationship between the phenomena observed.

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Let us acquaint ourselves with certain photographs transmitted by "Mars-5." They clearly show the regions of the Mare Erythraeum and the Bosporus (southern subtropical zone of Mars). The craters whose dimensions do not exceed 130 km are combined by a wide valley. In the upper left, there is the meandering bed of an ancient river.

These two craters can be seen to the right of the center of the preceding frame. The high resolution of the photographs makes it possible to study in detail the structure of the Martian craters. The enormous craters have a flat floor and sides which have undergone great wind erosion. In the small craters, there is a cup-shaped form.



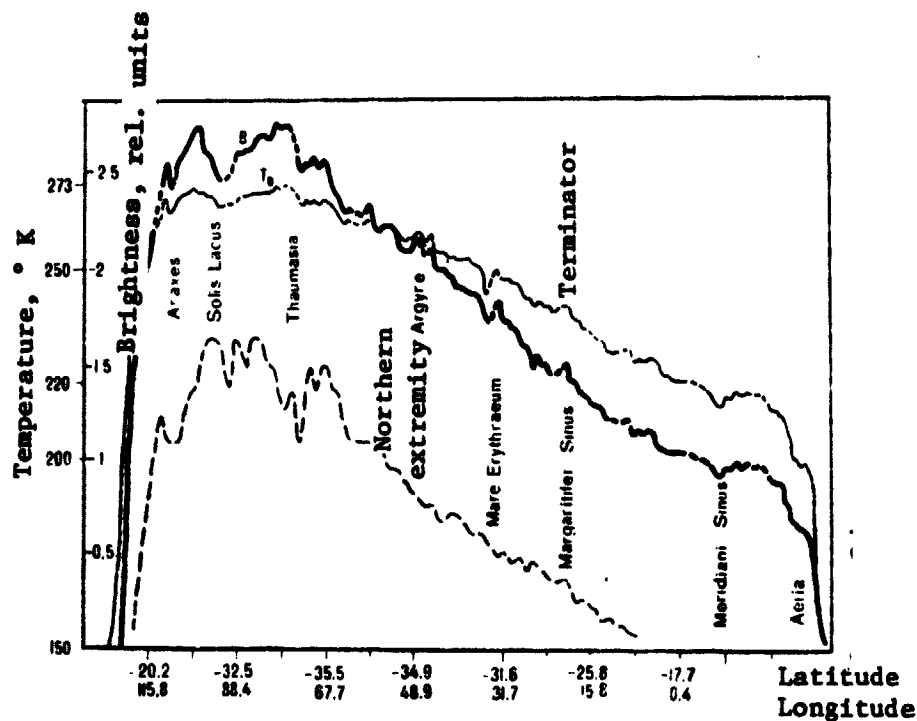
Relief (dashed line), theoretical brightness profiles corresponding to the Lambert reflection law (Z_0 curves) and brightness of the Martian surface recorded by the "Mars-5" photometer. In the mountainous region at a wavelength of 3200 Å, the surface brightness sharply decreases, and at a wavelength of 4900 Å (bluish color), it increases.

the light region of Arabia, at a latitude of about 10° and a longitude of about 320°.* If the old maps are used, the majority of the regions intersected are dark, although photometric measurements do not always confirm this.

It was autumn during the operation of "Mars-5" in the southern hemisphere. In 1974, the atmosphere of Mars was very transparent. This played an important role in the photography

*The Russian translation of the Latin names for details on the surface of Mars is contained in an article by D. Ya. Martynova "What is What on Mars" (Zemlya i vseleennaya, No. 3, 1974, pp. 21 - 27) or in the third edition of the Great Soviet Encyclopedia. — Editor.

"Mars-5" was launched into an orbit which was very close to the calculated orbit. Its period of rotation — 24 hours 53 minutes — almost coincided with the Martian day. Due to this fact, seven measurement trajectories took place over one and the same region, which made it possible to study it in great detail. The trajectories which would begin close to the Equator at 130° longitude (region of Memnonia) were deflected toward the south to -36° in the region of the Bosphorus, intersected the terminator between the 10 — 20° longitudes in the region of Margaritifer Sinus, and then in the northern hemisphere descended to the planet in

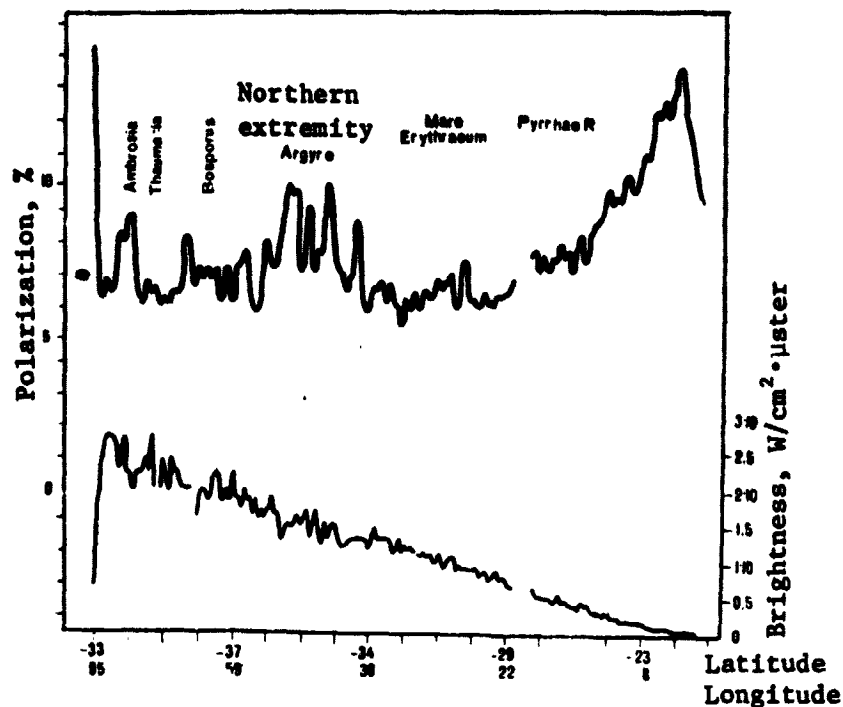


Brightness temperatures of the surface (T_B) and the thermal fluxes (B) along the trajectory on 23 February 1974. The dashed line shows the brightness curve at a wavelength of 1.78μ (reflected solar light).

of the surface of the planet. In one of the numerous photographs, scientists discovered the well-known meandering bed of a dried up river, whose picture was transmitted by "Mariner-9" in 1972. A name has already been given to it, "Nigral." It is not possible to determine the age of this formation with great reliability. Probably it is many millions of years or even billions of years old. In other words, Nigral is ten times older than the Indian Ocean.

A portion of the photographs were made with a very high resolution — up to tenths of a kilometer; others encompass very extensive regions of the surface. Color photographs were obtained of the surface of Mars. In these photographs, the floor of some craters has a dark green color, which stands out

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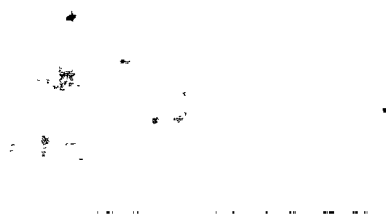


Polarization of light and surface brightness at a wavelength of 6000 Å along the trajectory on 23 February 1974. The region of increased polarization corresponds to the northern extremity of Argyre and is related to large particle dimensions on the surface. It follows from the brightness curve that this region is one of the darkest regions.

sharply from the overall orange background. If the correctness of the color image is substantiated, this may mean that the floor of such craters is composed of rocks other than those of the surrounding surface. Is it possible that on Mars there is vegetation in these craters?

Television images of the red planet were obtained not only from "Mars-5," but also from "Mars-4," which flew around Mars. Very interesting panoramas of the surface were transmitted by "Mars-4 and -5."

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Crater with a diameter of 30 km with a well preserved
embankment.

March 12, 1974, was a very important day in the "Mars-73" program: the "Mars-6" station reached the surface of the planet. Descending into the atmosphere, it determined the atmospheric composition, and measured the pressure and temperature. The results of determining the atmospheric composition were unexpected. Before the flights of "Mars-3" and "Mariner-9," the content of argon in the Martian atmosphere was not known. It remained unknown after a detailed analysis of the data obtained by the spacecraft. A mass-spectroscopic gas analyzer on "Mars-6" established that the argon in the Martian atmosphere is $35 \pm 10\%$. This is a very large amount. The concentration of inert gases in the atmosphere is connected not only with the composition of the surface of the planet, but also with its history and conditions of formation. Therefore, such a high content of argon requires an explanation. If the liberation of argon from the surface of Mars is the same as from the Earth, its primary concentration in the atmosphere must also comprise several percents. It has been proposed that, as the carbon dioxide at the polar caps freezes, the atmosphere is enriched with argon, which does not freeze at the temperatures existing on Mars.

There are several new results regarding the atmosphere of Mars. The change in the phase of the signals from the onboard radio transmitters was used to find the concentration of electrons in the nocturnal ionosphere. It comprises $6 \cdot 10^5$ electrons per 1 cm^3 , whereas in the daytime, its content increases to $1.5 \cdot 10^5$. Thus, future expeditions on Mars can probably maintain radio communication between themselves at wavelengths which are longer than 500 — 1000 m.

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In the atmosphere of Mars, there is now much larger amounts of water vapor than during the operation of "Mars-3." The amount of precipitated water in places reaches 60 -- 70 which is 3 — 5 times greater than the values obtained by "Mars-3." It is also interesting to note that the distribution of vapor over the surface is not uniform.

"Mars-5" also carried two polarimeters to study the structure and photometric properties of the surface. This experiment was performed concurrently with Soviet and French scientists. The polarization of light, which arises during its reflection from the surface of the planet, carries indirect information regarding the surface itself. The results of the polarimetric experiment showed that the polarization of light is much less than was expected. The greatest amount of polarization, which was observed close to the northern extremity of the Argyre sea, barely reached 10%, which is 2 — 3 times less than the values for the Moon. This means that the surface of Mars is covered by a layer of finely pulverized material with properties which differ greatly along the trajectory. As a rule, the polarization values are much greater for samples studied on the Earth. There is a hypothesis that finely pulverized mixtures of goethite with rhyolite give similar results, with grain dimensions from 25 to 60 microns.

Data transmitted by an infrared radiometer also point to the very pulverized nature of the surface rocks. The brightness temperatures measured along the trajectory (temperatures of the surface) are very close to the theoretical temperatures of greatly pulverized rock. The maximum temperature recorded was 272° K (-1° C) at 13 hours local time. It is remarkable that a temperature peak was observed in the region of Claritas at 11 hours 30 minutes local time. There was an unusual behavior

of the brightness curves between 1.5 and 2.0 microns, which are correlated with the behavior of the temperature, although the inverse relationship must hold. At the setting of the Sun, the temperature decreases to 230° K, and at 21 hours local time — to 200° K. It is interesting to note that there has still been found no dependence between the relief and the temperature.

The relief undergoes great altitude jumps along the trajectory. This was observed by a special spectroaltimeter carried onboard "Mars-5." In the region of Claritis-Thaumasia, which was assumed to be a very mountainous plateau based on data from "Mariner-9," the altimeter recorded several mountain peaks 8 — 11 km high and with very smooth sides. Here (Ambrosia) there is very high polarization, pointing to differences in the structure of the surface. However, neither the altitude nor the structure of the surface exhaust the surprises of this region. The scientific equipment included several photometers which covered the 3200 — 7500 Å spectral region. The shortest wavelength region may also be used to measure the altitudes. The brightness profile at a wavelength of 3200 Å shows a deep dip in the mountainous region. At a wavelength of 4900 Å, the profile of the brightness undergoes a sharp rise in the region of the mountains, and at a wavelength of 4100 Å, the rise is much less. Thus, it may be concluded that these mountains have a bluish color.

The processing of data from "Mars-5," which reported a great deal of new information regarding the planet, has provided only very preliminary but very interesting results. New concepts and new conclusions lie on the road ahead.

Translated for National Aeronautics and Space Administration
under Contract No. NASw-2483 by SCITRAN, P. O. Box 5456,
Santa Barbara, California, 93108.